A Wireless Test-bed of Front Wheel Drive Wheelchair for Stability Control Prototyping

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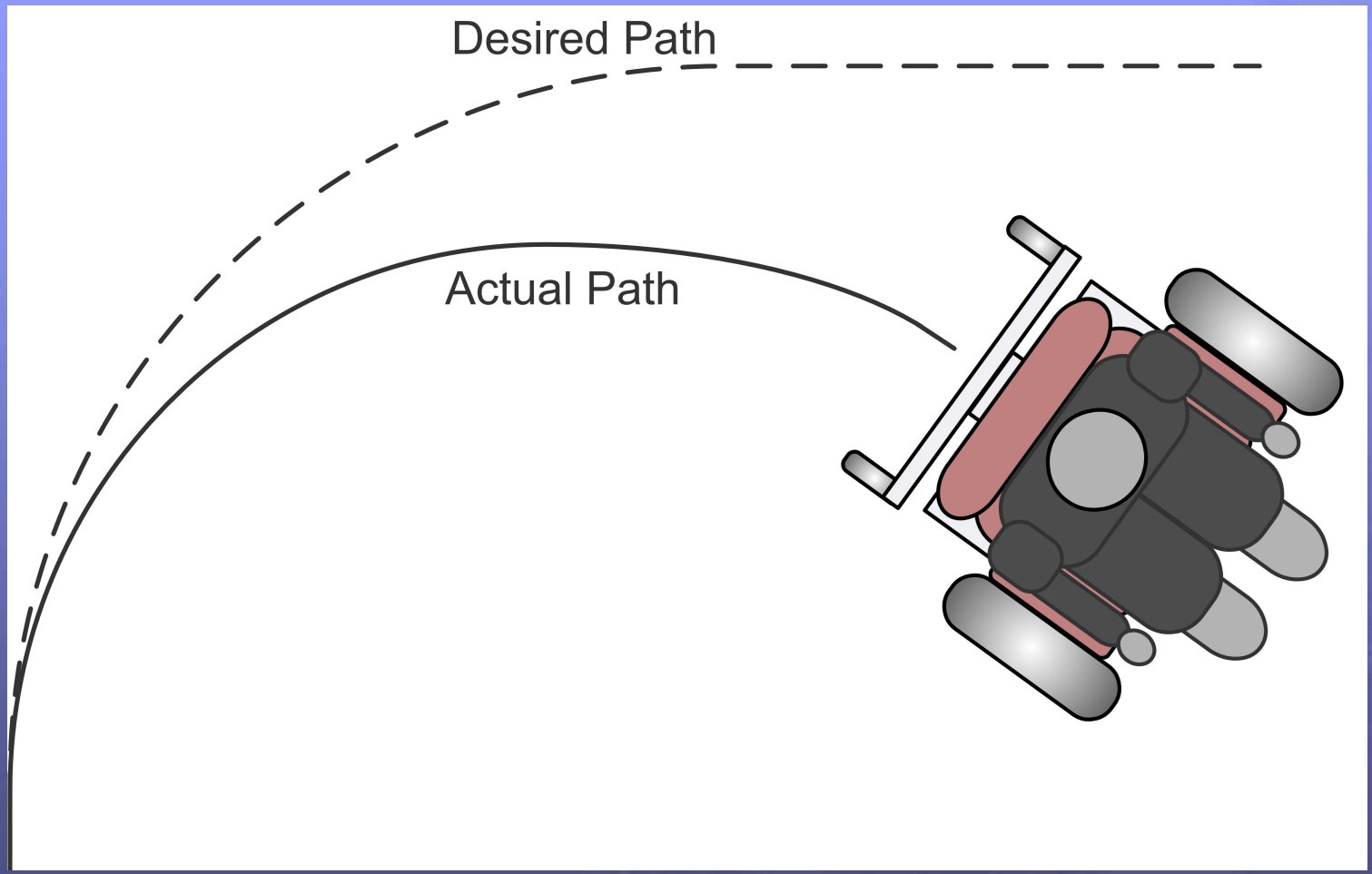
What?

- **Providing dynamic stability to FWD wheelchairs using feedback control via solid state sensors**

- Why FWD w/c's?

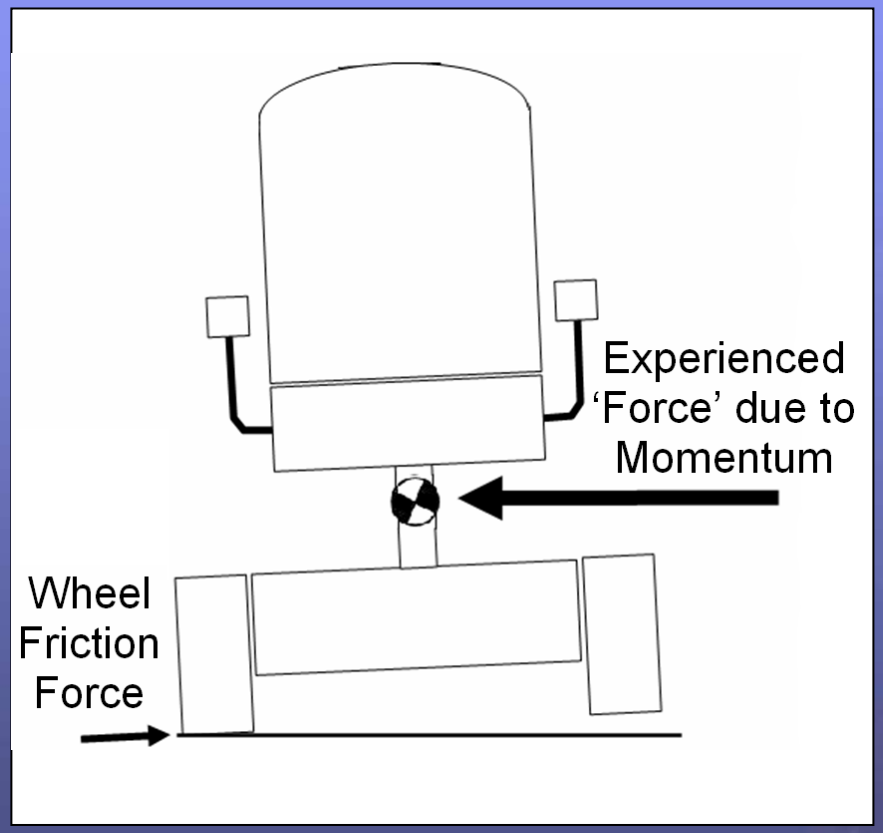
- What instabilities?

What Happens…



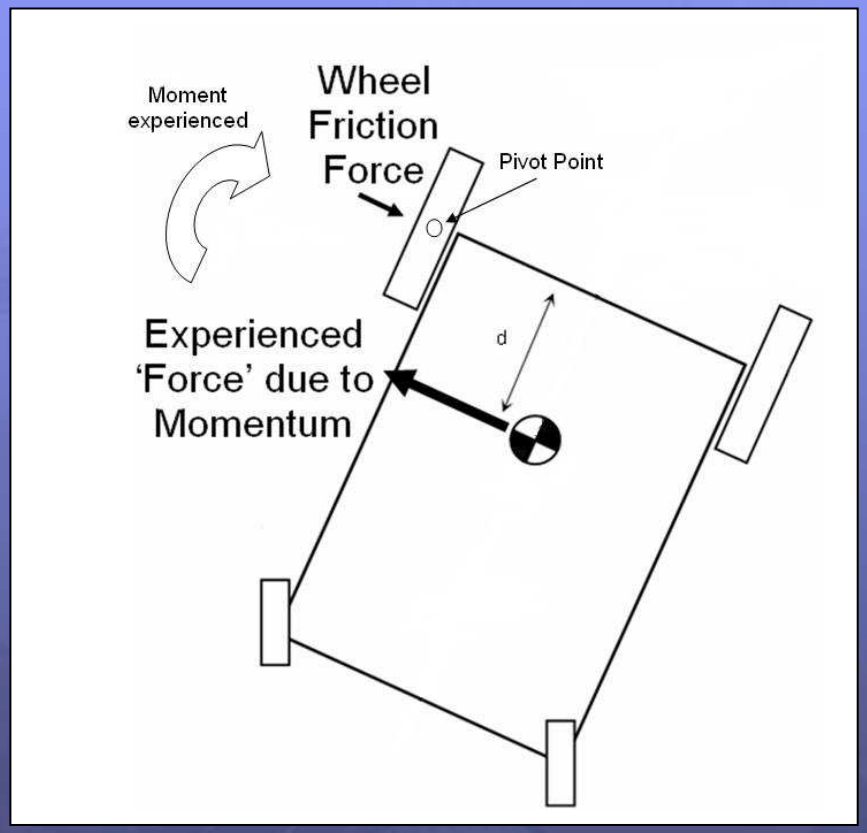
Inherent Instability → Poor Control

Front View



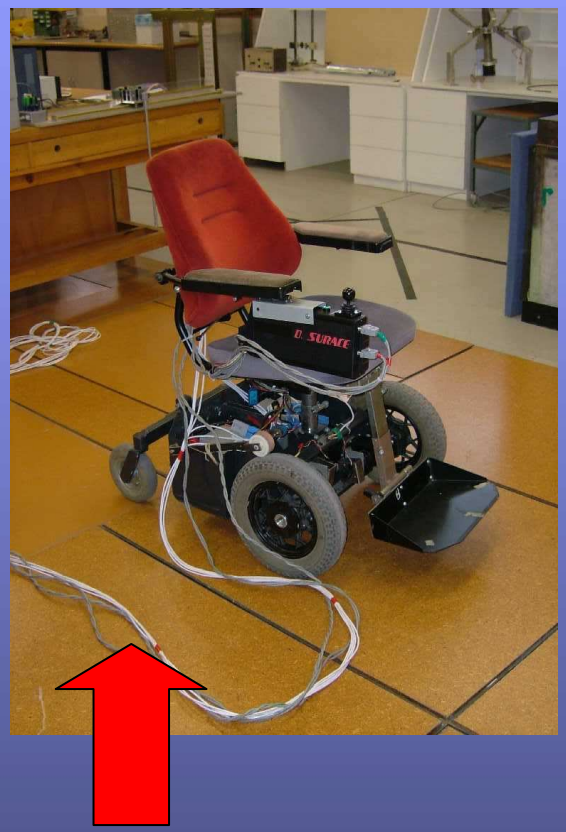
Over-steer due to high centre of gravity

Plan View



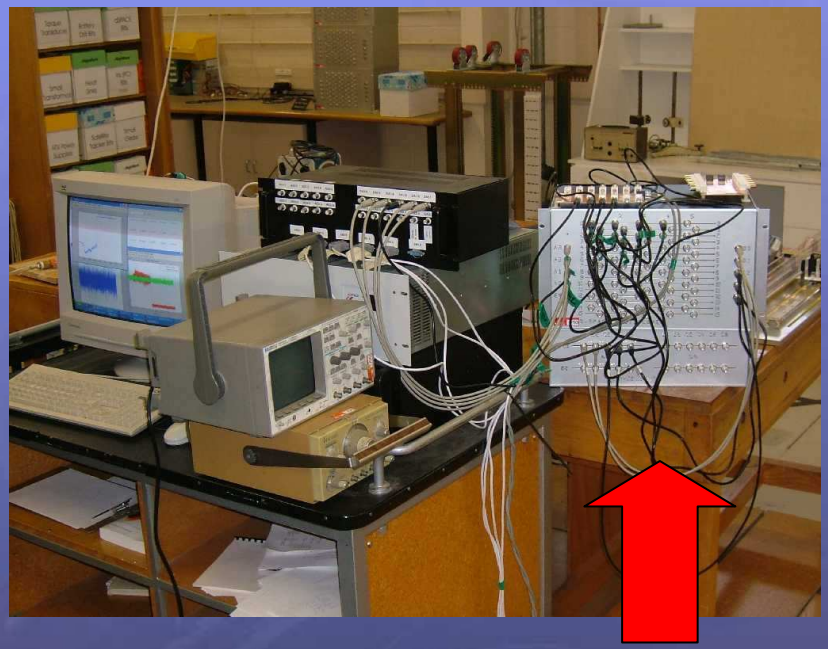
Over-steer due to centre of gravity location

First Testbed = Many Wires



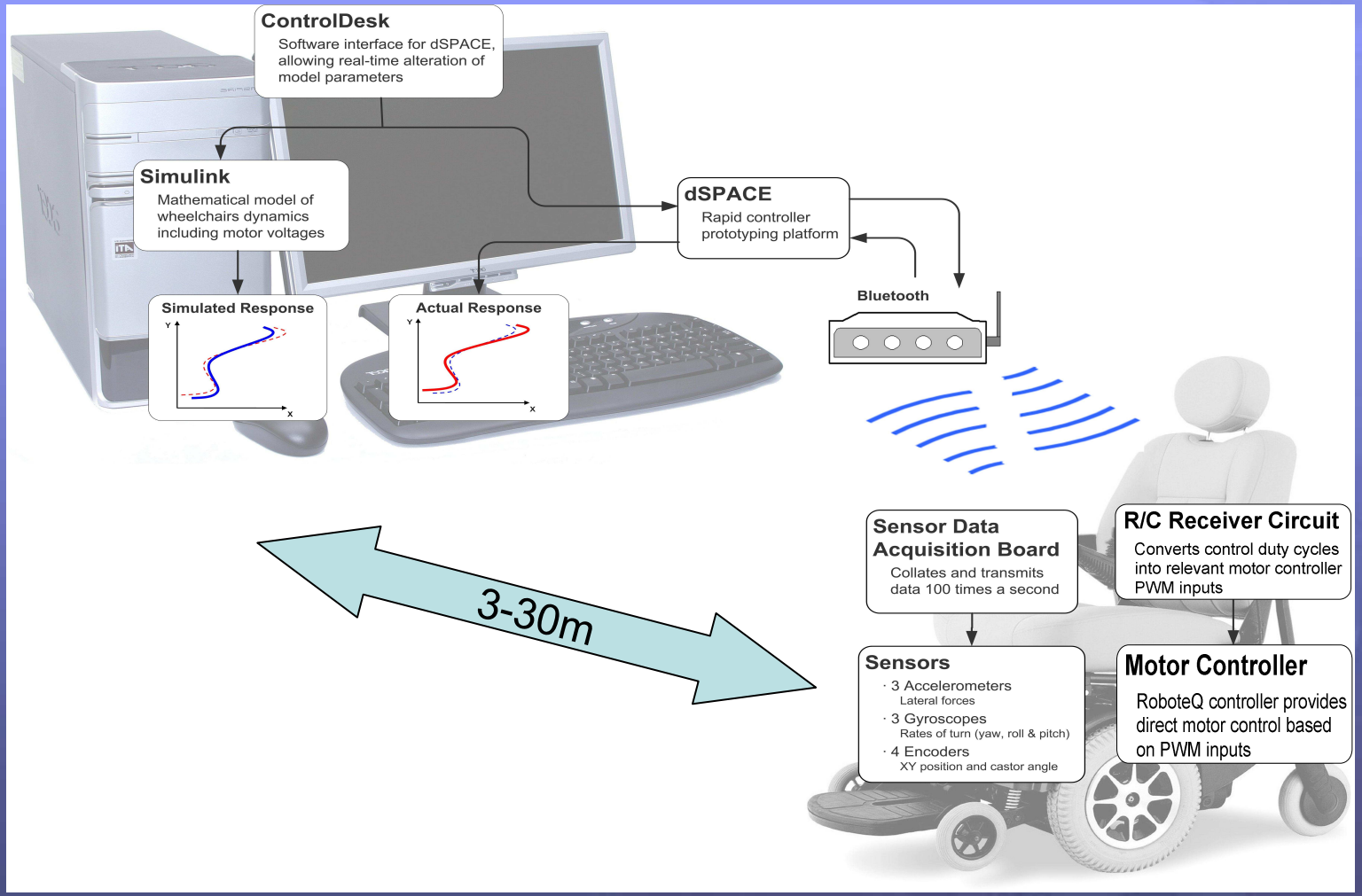
Wires = Antennae → Massive signal interference

Problem → Hard and Mobility → Zero



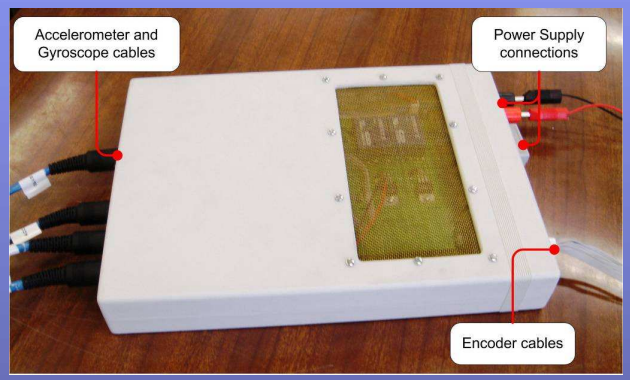
Only a truly wireless test bed will allow proper development for stability control

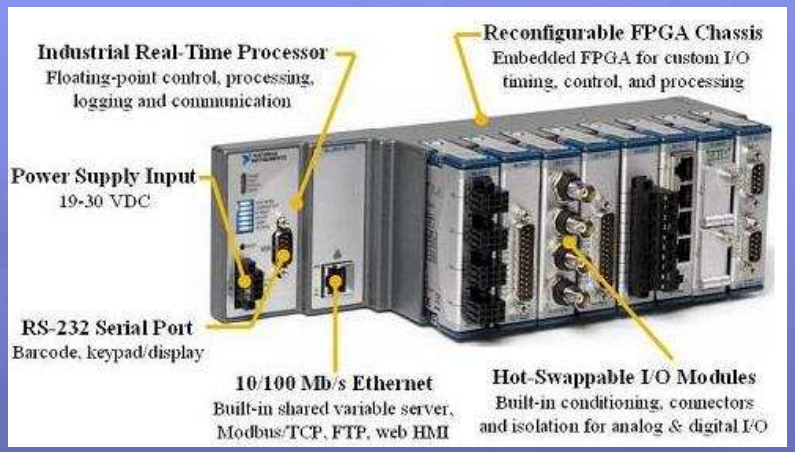
Wireless Testbed



Goals and Gear

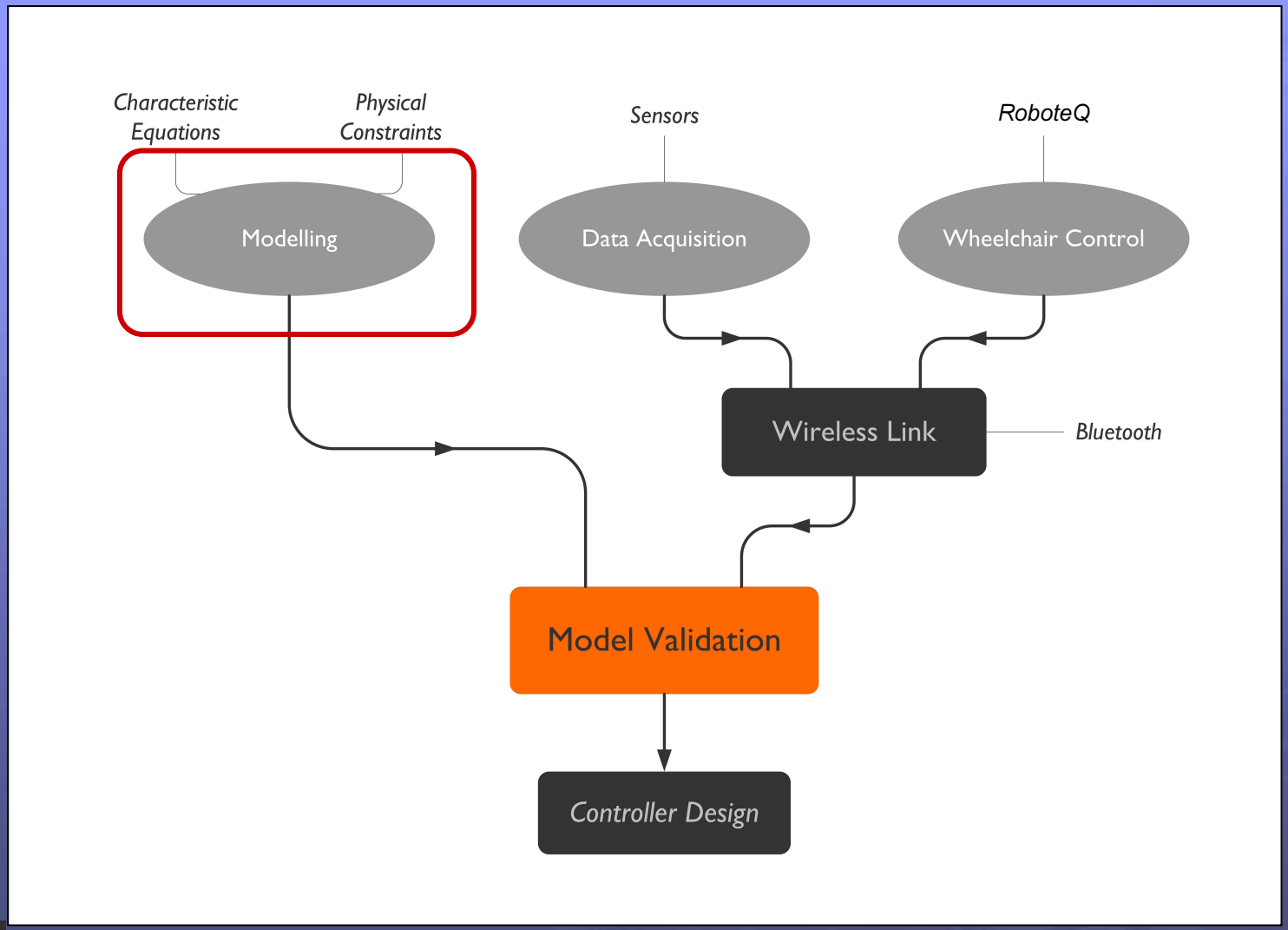
- **Complete wireless wheelchair test bed**
  - Replace sensor data acquisition device with National Instruments RIO



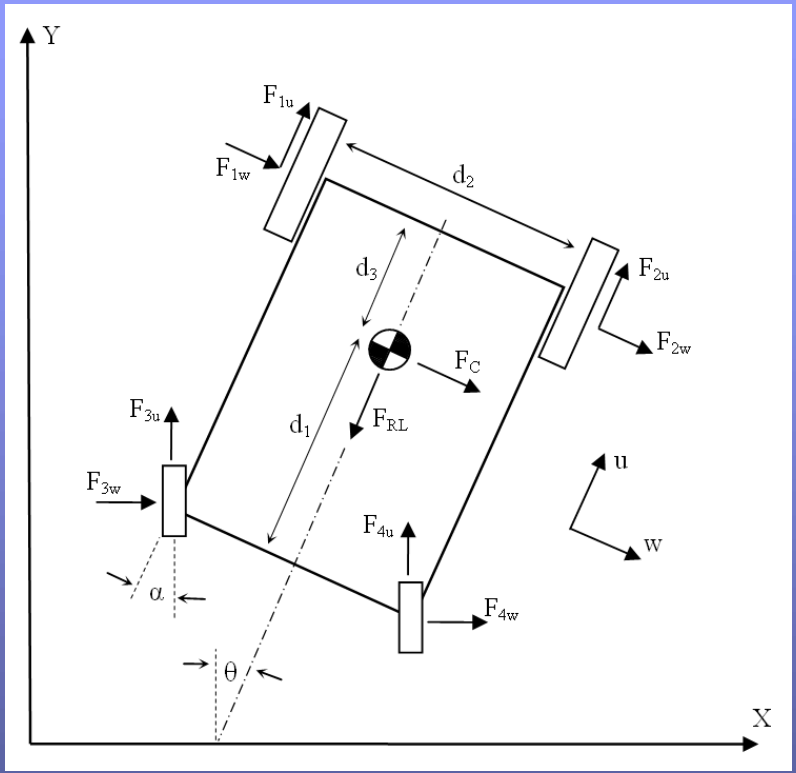


- **Use the test bed to validate dynamic system models**
- **Create the foundation for future model-based control design**

Modelling


Characteristic Equations
Physical Constraints
Modelling
Sensors
Data Acquisition
RoboteQ
Wheelchair Control
Wireless Link
Bluetooth
Model Validation
Controller Design

Modelling



- Dynamic Model
  - Forces, Moments on chair
- Physical Attributes
  - Inertias, Centre of Gravity, etc
- Motor Constants
  - Calculate speed and torque constants

INPUT

Motor Duty Cycles

OUTPUT

XY Position of Wheelchair

Modelling

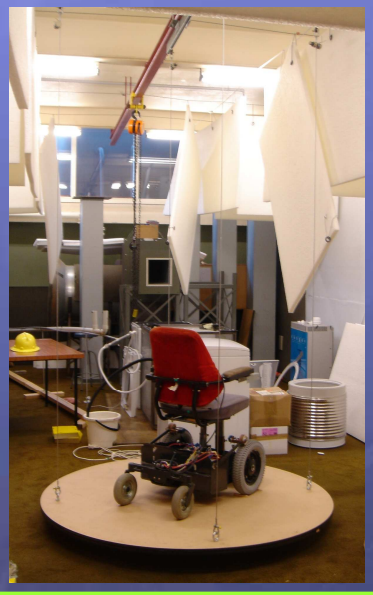
- Forces and Moments

$$ma_w = m(\dot{v}_w - v_u) = F_{1w} + F_{2w} + F_{3w}\cos\alpha + F_{4w}\cos\alpha - F_{3u}\sin\alpha - F_{4u}\sin\alpha$$

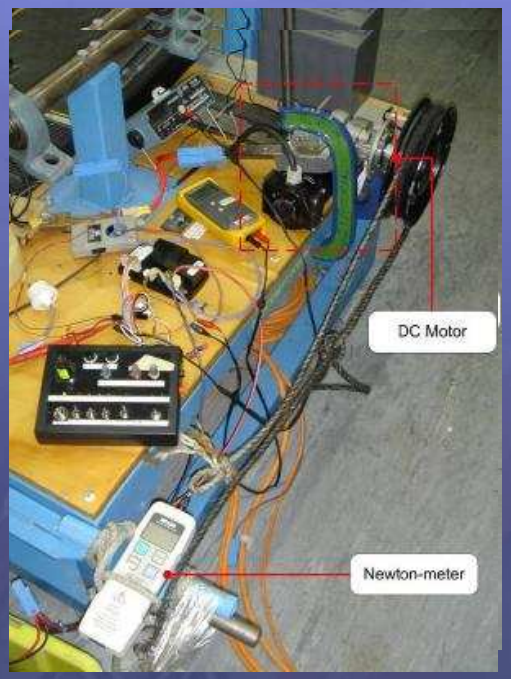
$$ma_u = m(\dot{v}_u - v_w) = F_{1u} + F_{2u} + F_{3u}\cos\alpha + F_{4u}\cos\alpha + F_{3w}\sin\alpha + F_{4w}\sin\alpha + F_{RL}$$

$$I_z\ddot{\theta} = (F_{1w} + F_{2w})d_3 + (F_{1u} - F_{2u} + F_{3u}\cos\alpha - F_{4u}\cos\alpha + F_{3w}\sin\alpha - F_{4w}\sin\alpha)\frac{d_2}{2} + (F_{3u}\sin\alpha + F_{4u}\sin\alpha - F_{3w}\cos\alpha - F_{4w}\cos\alpha)d_1$$

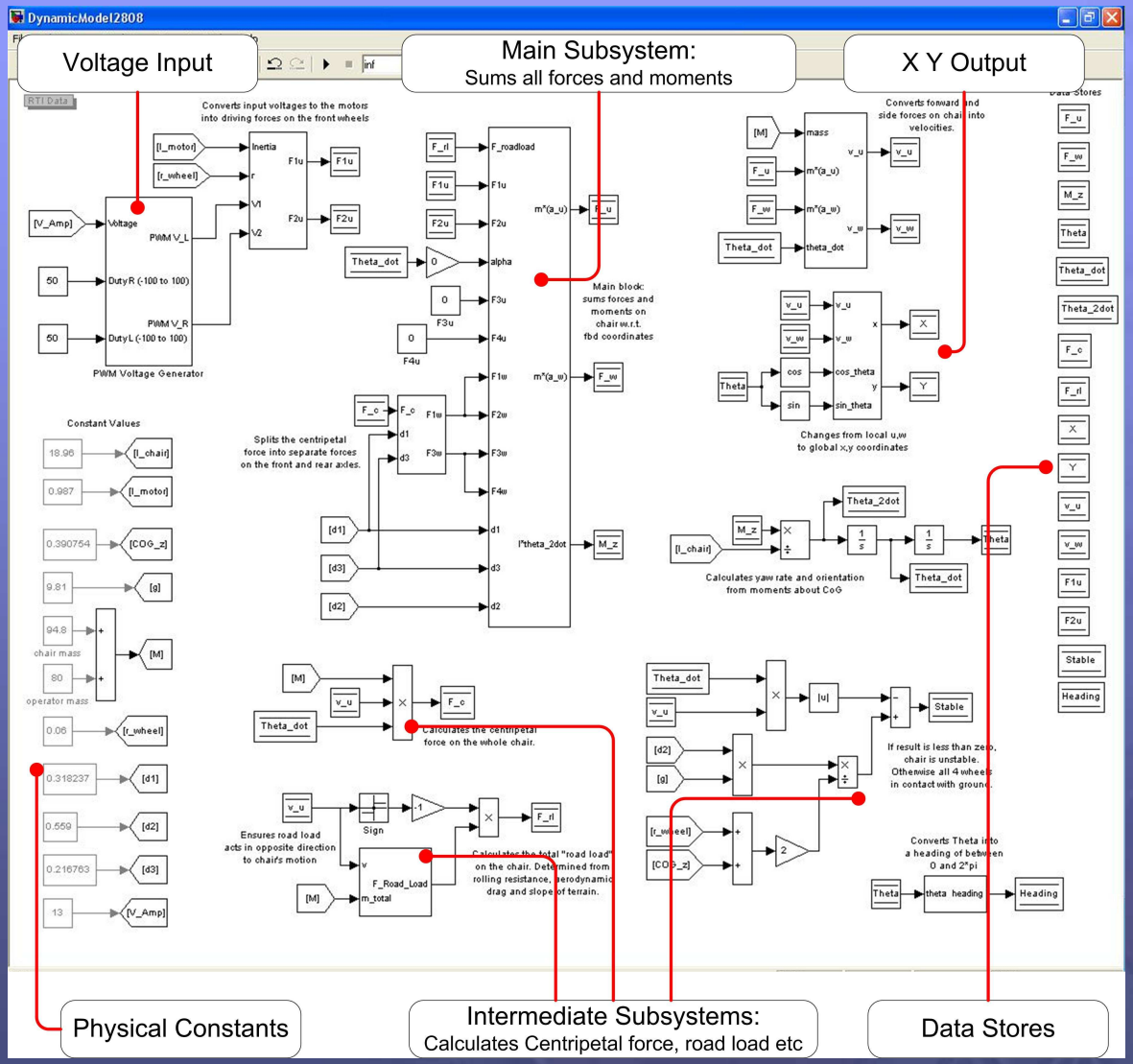
- Physical Attributes



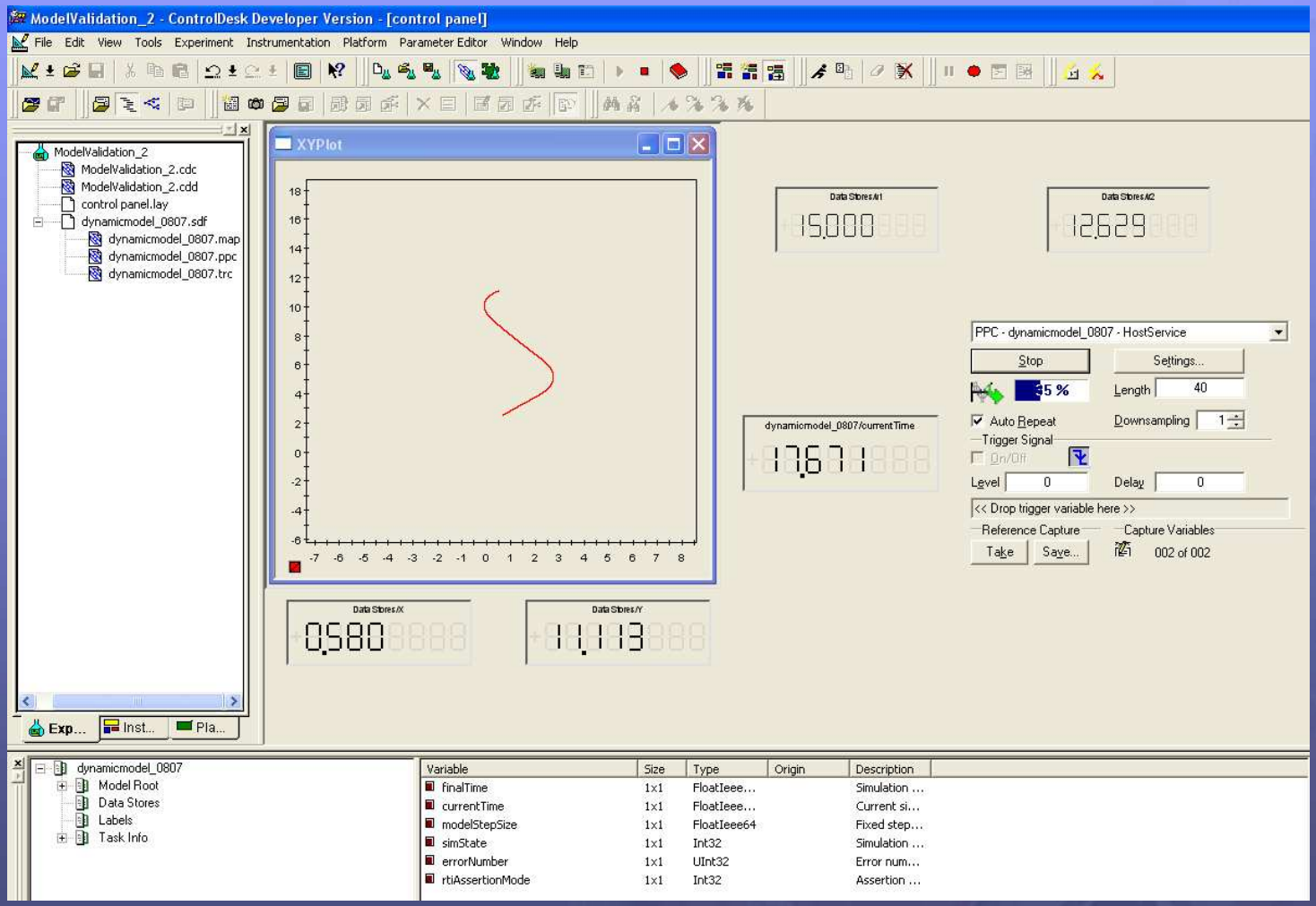
- Motor Constants



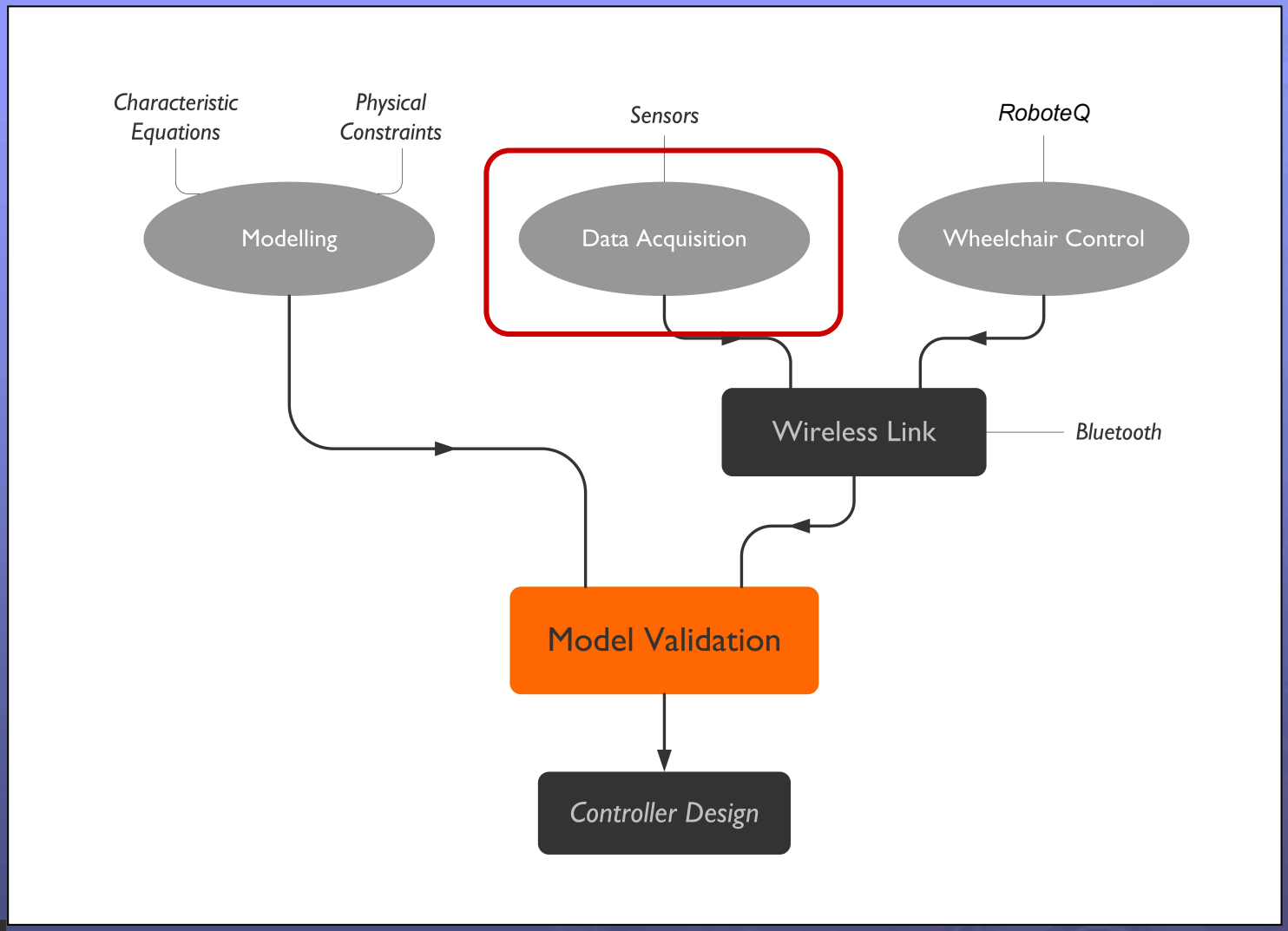
Simulink Model



Model Testing in ControlDesk



Sensors


Characteristic Equations
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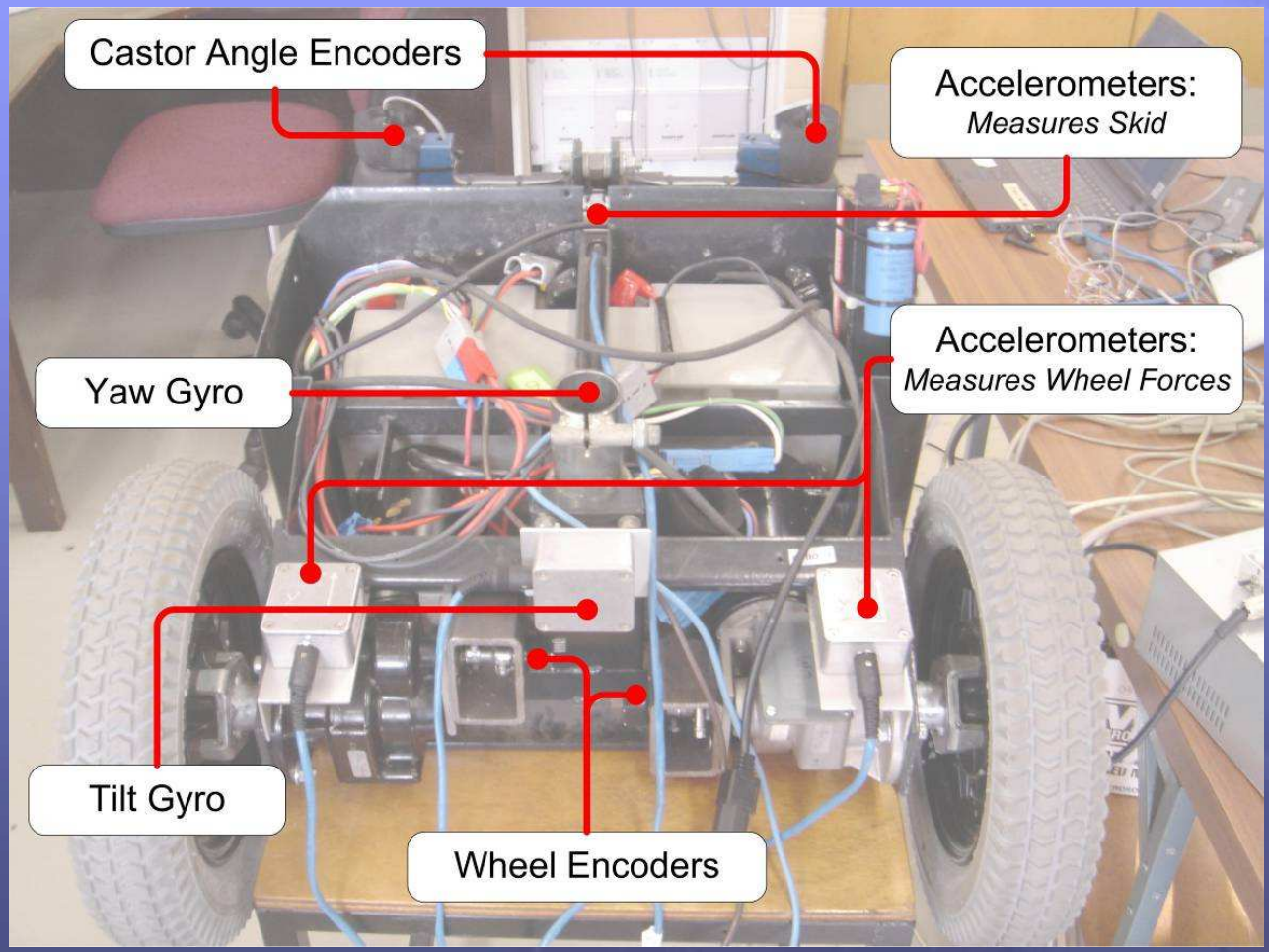
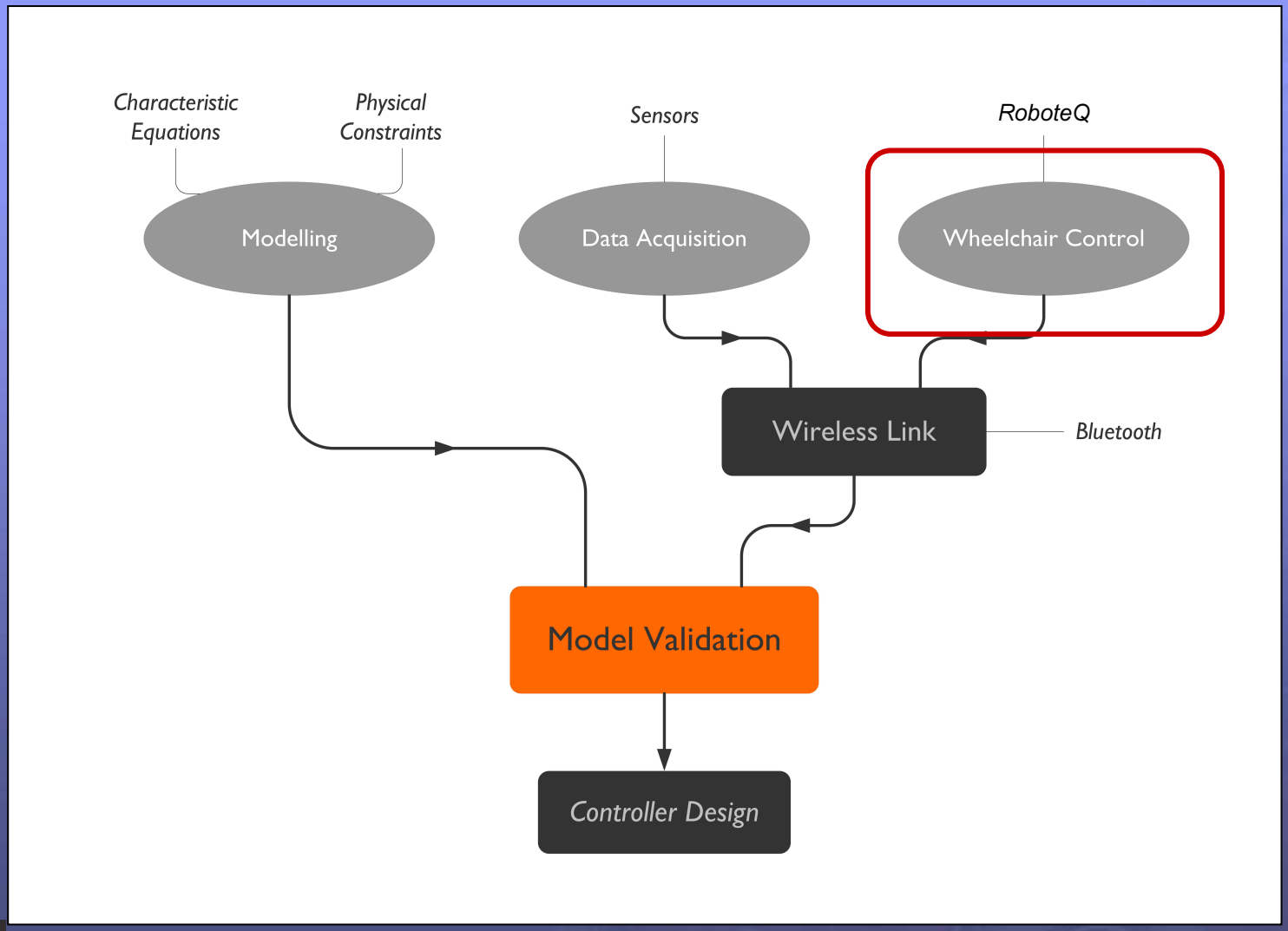
Redundant Sensors for Design

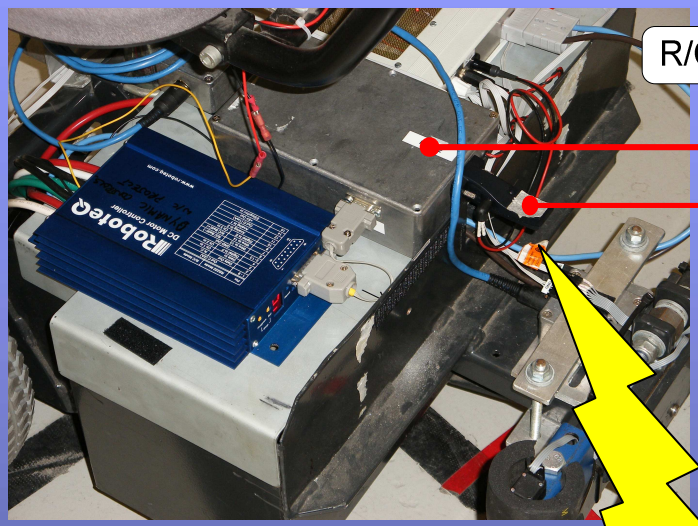


Goal is to find best combinations of sensors (minimum set)

Wheelchair Control

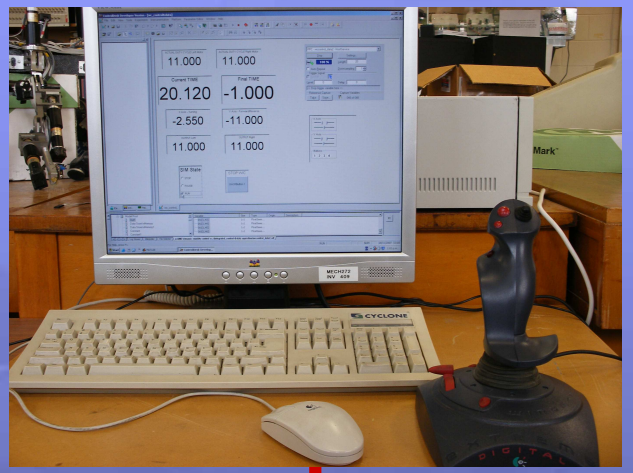


Wheelchair Control



R/C Receiver Circuit

BT device



Summary

- A wireless test bed is completed
  - Several sensor choices to find a best minimal set for stability control and better performance at low cost
  - Wireless driver is required to have freedom to really test stability versus simple handling issues
  - Testbed uses dual channels to test feedback stability control, rather than 1-way driving only.
  - Design created offers an efficient low-cost method of developing these systems
- A computational stability model will be verified using this test bed (ongoing)

Questions?

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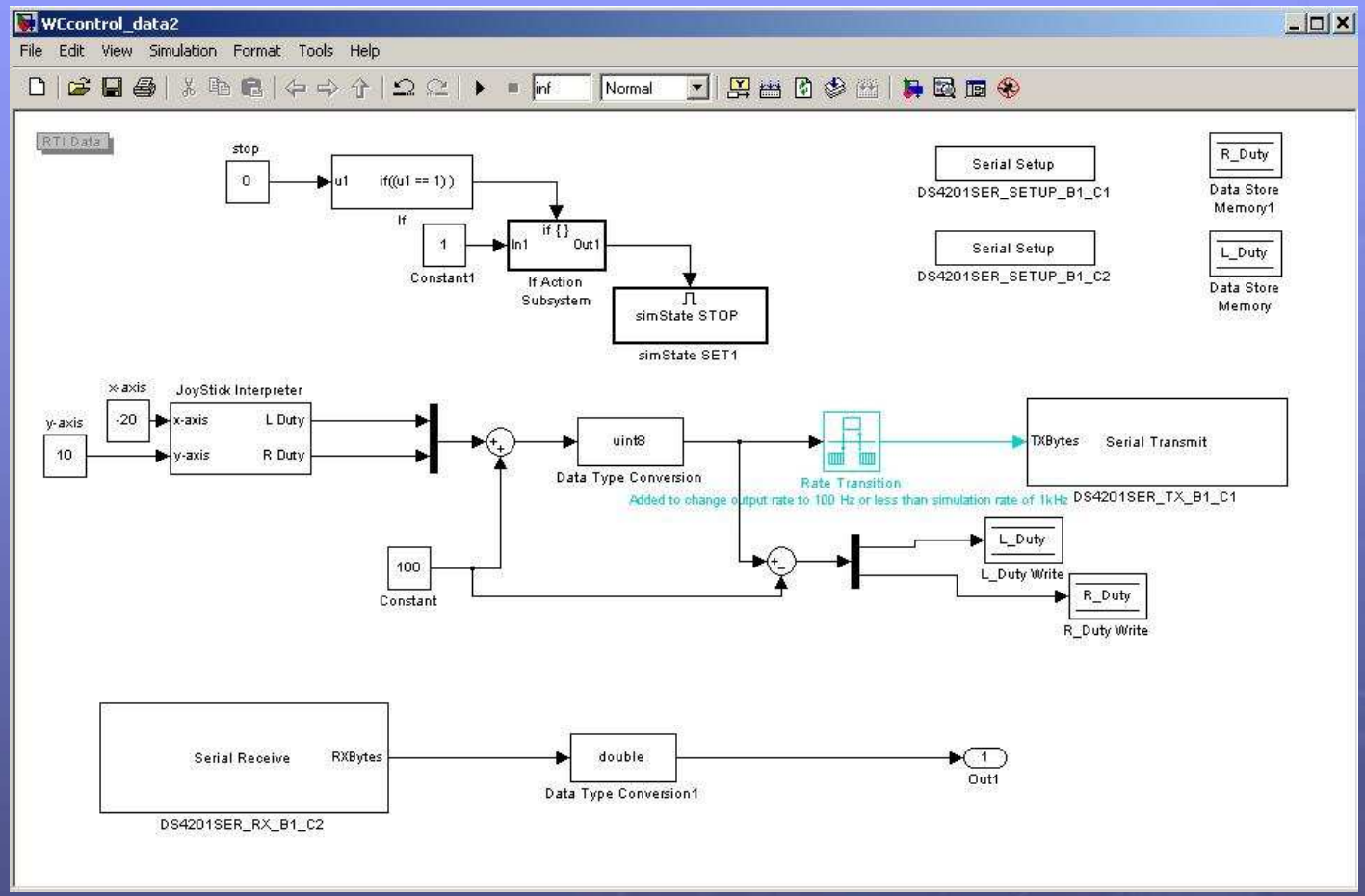
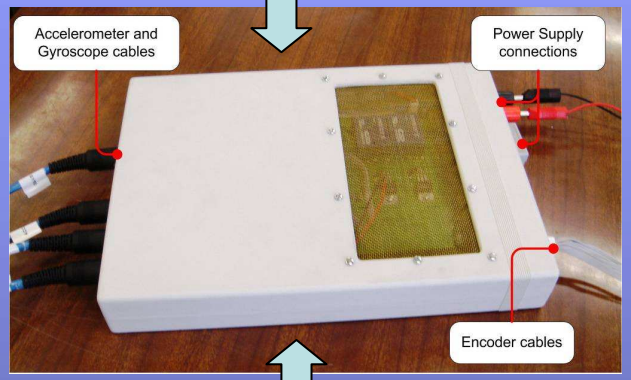
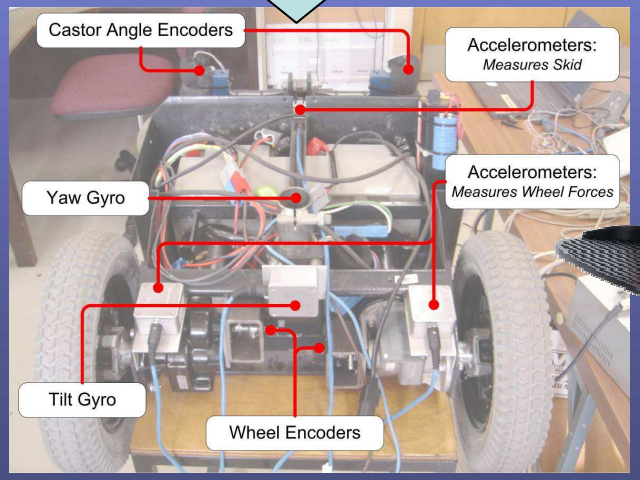
Wheelchair Control



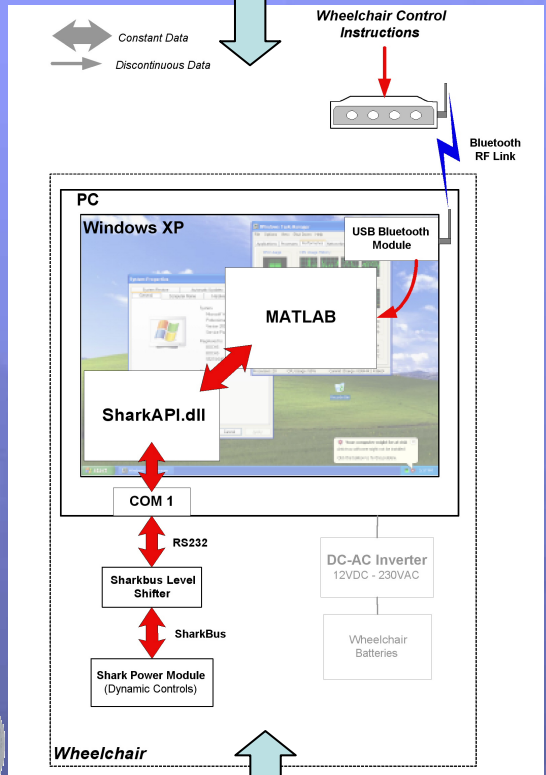
On the Chair

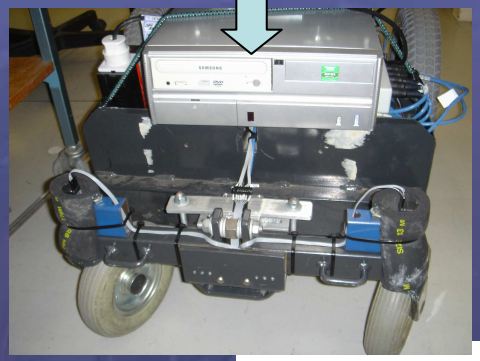
Bluetooth





Bluetooth





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Decoded Sensor Data